MOLECULAR TOXICOLOGY STUDIES

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MOLECULAR TOXICOLOGY STUDIES
Scientific Basis

- Altered Molecular Function
- ↓
- Altered Cellular Function
- ↓
- Altered Organ Function
- ↓
- Disease

MOLECULAR TOXICOLOGY STUDIES
Approaches

- Evaluate effect of test agents on biologically important molecules or key cellular functions.
- Quantify absorbed and/or biologically effective dose of test agents in living systems.

MOLECULAR TOXICOLOGY STUDIES
Model Systems

- *In vitro* Studies
  - Condensate
  - Whole smoke
- Rodent Studies
  - Condensate dermal studies
  - Whole smoke inhalation studies
- Studies in Smokers

MOLECULAR TOXICOLOGY STUDIES
Dose Selection

- Experimental design should be comparative.
- Test and Reference cigarettes are evaluated at concentrations where the Reference cigarettes induce a concentration-dependent positive response.

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Model Systems

- *In vitro* Studies
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  - Condensate dermal studies
  - Whole smoke inhalation studies
- Studies in Smokers

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Source: https://www.industrydocuments.ucsf.edu/docs/fgdk0001

Preparation of Mainstream Cigarette Smoke Condensate for *In Vitro* Studies

- Cigarettes were smoked under standard FTC conditions and the particulate matter collected on Cambridge pads.
- DMSO was added to yield a concentration of 10 mg TPM/ml DMSO; the pads were shaken for 25 minutes.
- The pads were removed to provide the dosing solution.

In Vitro Studies

- Cytotoxicity
- Genotoxicity

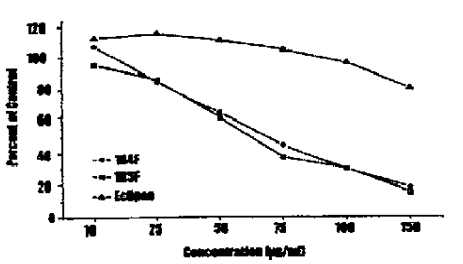
In Vitro Cytotoxicity Rationale

- Mechanistically important step in several chronic disease processes (e.g. carcinogenesis, emphysema)
- Determination of appropriate exposure concentrations for *in vitro* genotoxicity assays
- Minimizes use of animals for toxicological assessment

Cytotoxicity Endpoints

- Lactate Dehydrogenase
  - Measures structural damage to the cellular plasma membrane.
  - Most useful for short term exposure to test agent (ca. 1 hr.)
- Neutral Red Assay
  - Measures cell killing and/or reduction in cell growth
  - Most useful for longer term exposure to test agent (ca. 24 hr.)

Neutral Red Cytotoxicity Assay of CSC CHO Cells



Cytotoxicity of CSC and Whole Smoke from Cigarettes with or without the Carbon Filter

Cigarette	CSC EC_{50} (ug CSC/ml)	Whole Smoke EC_{50} (Cigarettes/M^3)
Control	64.9 +/- 9.5	5.1 +/- 0.6
Control with Carbon Filter	54.5 +/- 10.1	10.1 +/- 0.6

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Source: https://www.industrydocuments.ucsf.edu/docs/fgdk0001

GENETIC TOXICOLOGY

The Study of the Interaction of Test Agents with DNA

OBJECTIVE: To characterize and define the potential of test agents to adversely affect the structure or function of DNA molecules.

Genetic Toxicology Rationale

- Genotoxic potential has been associated with carcinogenic potential.
- DNA damage in germ cells may produce heritable defects.

- ICH Tripartite* guidelines on genotoxicity testing of pharmaceuticals for human use
  - Bacterial reverse mutation test
  - An *in-vitro* test with cytogenetic evaluation of chromosomal damage in mammalian cells
  - An *in-vivo* test for genetic damage

[*European union, Japan and USA]

Genetic Toxicology Testing Program

- ***In vitro*** **Studies (effects)**
  - Bacterial Cells
  - Mammalian Cells
- *In vivo* Studies (dosimetry)
  - Rodents
  - Smokers

Genetic Toxicology Endpoints *In Vitro*

- Ames Test - uses special strains of bacteria to evaluate the frequency of genetic mutations
- Sister Chromatid Exchange - evaluates the frequency of genetic material changing locations within the mammalian chromosome.

Genetic Toxicology Endpoints

- Chromosome Aberration - evaluates the structure of mammalian chromosomes.

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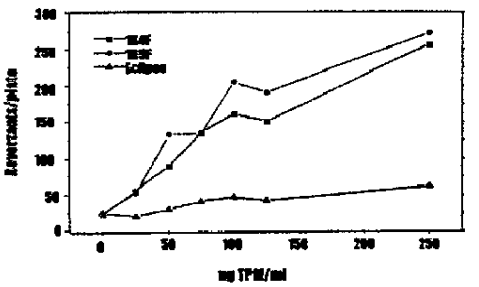
Ames Test
TA98 with S9 Metabolic Activation



In Vitro Genetic Toxicology Tests Summary
Cigarette Smoke Condensate*

	Ames	Sister Chromatid Exchange	Chromosome Aberration
Eclipse	—+	—+	——
1R4F Reference	+++++	+++++	+++++
1R5F Reference	+++++	+++++	+++++

*Comparisons made on a "per mg" basis

Genetic Toxicology Testing Program

- *In vitro* Studies (effects)
  - Bacterial Cells
  - Mammalian Cells
- *In vivo* Studies (dosimetry)
  - **Rodents**
  - Smokers

DNA ADDUCTS

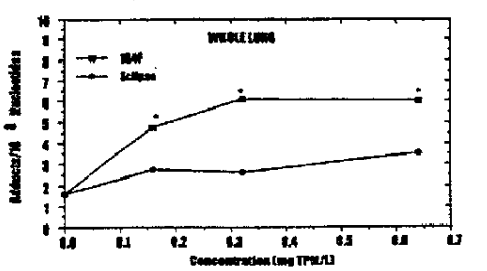
- Dosimeter for Chemical Exposure of DNA in Specific Target Tissues

^{32}P Post-Labeling

Advantages: 1) Sensitive (1 adduct in 10^{10} normal nucleotides)
2) Quantitative
3) Widely used
4) Prior knowledge of adduct composition not necessary (particularly valuable for complex mixtures)

Disadvantages: 1) Very small DNA modifications (i.e., methylations) not efficiently detected
2) Don't know chemical identity of the adducts

Sub-Chronic Inhalation Exposure
90 Days
B6C3/F1 Male Mice



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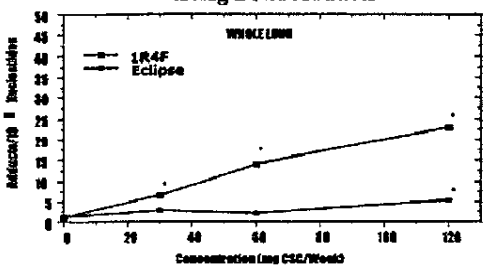
29 Week Dermal Exposure SENCAR Female Mice Lung DNA Adducts



Genetic Toxicology Testing Program

- *In vitro* Studies (effects)
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- *In vivo* Studies (dosimetry)
  - Rodents

–Smokers

URINE MUTAGENICITY

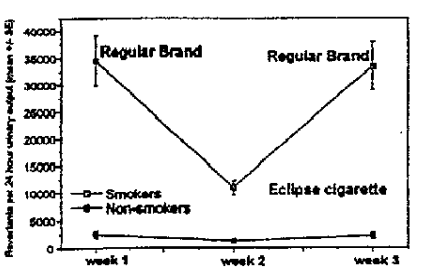
- Urine is a major excretion route for most xenobiotics.
- Urine is collected, concentrated and tested in AMES bacterial mutagenesis assay.
- Urine mutagenicity reflects an individual's recent exposure to mutagens.

Experimental Design

		Week No.		
	#	1	2	3
Smokers	23	Usual brand	Eclipse	Usual brand
Non-smokers	10	None	None	None

NOTE: All subjects remain on a controlled diet for a 3-week period.

Urinary Mutagenicity Study TA98 5% S9



RESULTS

- Usual brand and *Eclipse* cigarette consumption per day was not statistically different.
- Salivary cotinine levels for subjects when smoking usual brand or *Eclipse* were not statistically significantly different.

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Source: https://www.industrydocuments.ucsf.edu/docs/fgdk0001

CONCLUSION

A battery of appropriate molecular toxicology assays is effective for evaluating and comparing the toxicity of smoke from different cigarettes.

Effective Strategy for Assessing Risk Reduction in Cigarettes

Reduction of Chemical Substances
- ✓ Smoke Chemistry Studies

Less Toxicity
- ✓ *In Vitro* Toxicity Studies
- ● Animal Toxicity Studies

Reduced Effects in Smokers
- ● Smoking Behavior/Exposure Assessment
- ● Clinical Studies using Markers

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